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ABSTRACT

This booklet was written for elementary school teachers who want suggestions of the type of activities suited to a mathematics laboratory. The emphasis is not that of a thorough survey of the available activities. Instead, the author uses selected examples to describe the spirit of a laboratory environment. The suggestions include arrangements of groups, drawing and reading maps, applications of ratio to time problems, graphing student characteristics and finding mathematical ideas of our alphabet. (RS)

CREATING A MATHEMATICS LABORATORY ENVIRONMENT IN THE ELEMENTARY SCHOOL

Part I: The Classroom Without Special Equipment

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THE SCHOOL DISTRICT OF PHILADELPHIA

CREATING A MATHEMATICS LABORATORY ENVIRONMENT IN THE ELEMENTARY SCHOOL

Part I: The Classroom Without Special Equipment

Lore Rasmussen, Director
LEARNING CENTERS PROJECT,

THE SCHOOL DISTRICT OF PHILADELPHIA
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Introduction

In the last decade, the mathematics curriculum for the elementary school has undergone vast changes. Increasingly, children study topics and use terminology that their parents and teachers did not become familiar with until they were in high school or college. Many school systems have adopted new textbook series while others are making more gradual changes through enrichment materials. No school is completely untouched by the new mood in mathematics instruction.

The intention of most of the new programs is to allow children to discover key mathematical principles through activity. The new materials are usually written in an interesting style and have an appealing layout. Some publishers provide student kits with concrete materials to reinforce their texts. But in almost all of these programs, the steps toward discovery are frozen in a predetermined sequence within the pages of a text. Possibly because they are awed or confused by the new materials, or merely unfamiliar with them, far too few teachers actually dare to improvise in the mathematics classroom or allow themselves and their children free time to explore the world of number, shape, or size.

The following pages attempt to share some thoughts about the spirit of the mathematics laboratory environment as a place where children are given ample time to get away from textbooks and workbooks in order to engage in creative mathematical activities often of their own choosing and tied to their own experiences as individuals. The spirit of the "laboratory environment" as interpreted here is chiefly a point of view toward raising problems, asking questions and the acceptance of many varieties of techniques for finding answers to problems. Only in such a spirit can an environment rich in raw materials, tools, and teaching aids be brought into living use to stimulate and facilitate mathematical activity. Every classroom can therefore be a mathematical laboratory even before it is specially equipped and supplied.

The following pages describe some mathematical laboratory activities in three types of situations: (1) In self-contained classrooms without the use of special tools, equipment and materials, (2) In self-contained classrooms with special equipment, tools and materials, and (3) In specialized classrooms designed and equipped solely for mathematical activities.

MATHEMATICAL LABORATORY ACTIVITIES
WITHOUT SPECIAL EQUIPMENT:

Since mathematics is a universal human language which deals with number, relations, shape, size and space, it gets its stimulus and finds its application not only in the non-human world of things, but also in all the activities and environments where human beings relate to one another and to the world of things. It is therefore impossible to suggest in this paper more than a very few of the natural, everyday situations which can be treated mathematically. A classroom itself provides a very fine base for capturing the interest of children in mathematical questions and for generating mathematical laboratory activities. The following suggestions are therefore to be considered only as examples of the many activities that can be carried out in every classroom without changing markedly a course of study or without adding material equipment and supplies.

I. Glancing at the record book for a new year (even before the children arrive on the first day) the teacher can begin to consider a wide variety of mathematical questions about the school life of the whole class:

DATA COLLECTED BEFORE THE CHILDREN ARRIVE:

> "My class has about thirty boys and girls. They live in a variety of dwellings in a neighborhood (a definable geographic space within the community). They travel (through space) over some of the same streets to reach the school (a common terminal point). Here they are assigned to a classroom (a given geographic space within the building) and each child in turn is given a seat at a table (a given geographic space within the room). This organization holds only for the school year (a very specific part of the calendar year) and then only for that part of the week called 'the school day' and only that part of the day called 'the school hours.'"

Already there are dozens of mathematical problems and activities hidden in and suggested by these data.

A. MY CLASS HAS ABOUT THIRTY BOYS AND GIRLS:

It may be that of the 30 children in the class, 12 are boys and 18 are girls. There are various ways in which one can play around with regular subgroupings by sex. We can use the children themselves to form lines and arrays, use two types of counters to stand for the two sexes or draw pencil-paper diagrams.

What are all the possible regular sex groupings that can be made with our data (12 boys, 18 girls)? Let the children find them by trial and error. Some data, such as 15 boys, 8 girls will allow for only one grouping. This, too, should be discovered by experiments.

Here are the possible groupings for 12 and 18.

1.) As one row (a number line -- boys first, then girls

bbbbbbbbbbbbgggggggggggggggggg

3 6 9 12 15 18 21 24 27 30

(1 group of 30 children containing 12 boys and 18 girls)

2.) As two equal groups

bbbbbbggggggggg
bbbbbbggggggggg

} 2 groups of 15 children, each containing 6 boys and 9 girls

3.) As three equal groups

bbbbgggggg
bbbbgggggg
bbbbgggggg

} 3 groups of 10 children, each containing 4 boys and 6 girls

4.) As six equal groups

bbggg bbggg bbggg
bbggg bbggg bbggg

} 6 groups of 5 children, each containing 2 boys and 3 girls

These are all the ways. The last grouping names for us the ratio of boys to girls in the class. It is a 2 to 3 ratio. The following mathematical sentence describes all the groupings carried out above:

$1 \times (12 + 18) = 2 \times (6 + 9) = 3 \times (4 + 6) = 6 \times (2 + 3)$

If we look at the last grouping again, we see that in every group (and therefore in the total) two out of five children are boys, 2/5 are boys. For 30 children, there are 12 boys because $6/6 \times 2/5 = 12/30$. What percent of the children are boys?

To find the answer we must know how many boys there would be for 100 children. For 100 children, the number of boys would be 40. $20/20 \times 2/5 = 40/100$ Since "percent" means "for every hundred," 40/100 means 40%. There are therefore 40% boys and 60% girls in the class, or 2/5 boys and 3/5 girls.

B. THEY LIVE IN A VARIETY OF DWELLINGS IN A NEIGHBORHOOD (A DEFINABLE GEOGRAPHIC SPACE WITHIN THE COMMUNITY). THEY TRAVEL (THROUGH SPACE) OVER SOME OF THE SAME STREETS TO REACH THE SCHOOL (A COMMON TERMINAL POINT).

In what direction are the homes from the school?
How far in blocks (or in miles) are homes from school?
How many homes are within 2 blocks (2 miles) from school?
How many homes are between 2 and 4 blocks (or miles) from school?
How many homes are beyond a 4-block (or 4-mile) radius from school?

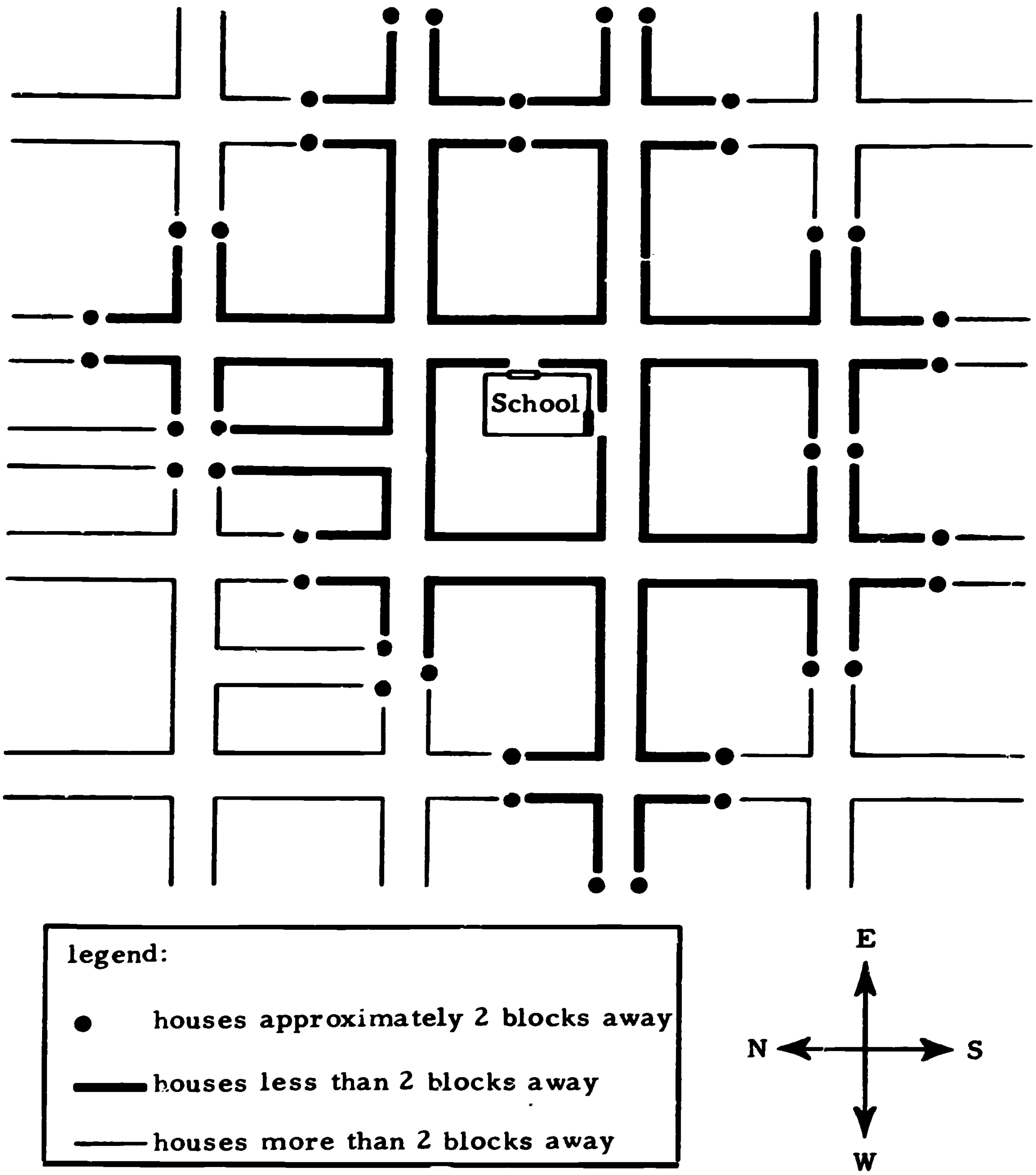
One interesting possibility is to locate the children's homes on a school district map. (The writer found that school offices have such maps that can be easily reproduced on a duplicator or can be enlarged with an overhead projector.)

a. On a large school district map, children find their homes and paste colored papers with their initials on them to show the locations of their homes.
Games can be played such as: Who can visit whom without crossing a street? Who lives less than a block (a mile) from Mary? Which children live farthest from one another? Who lives closest,

farthest from one another? Who lives closest, farthest from you? Who lives the same distance from school as you do? etc. . .

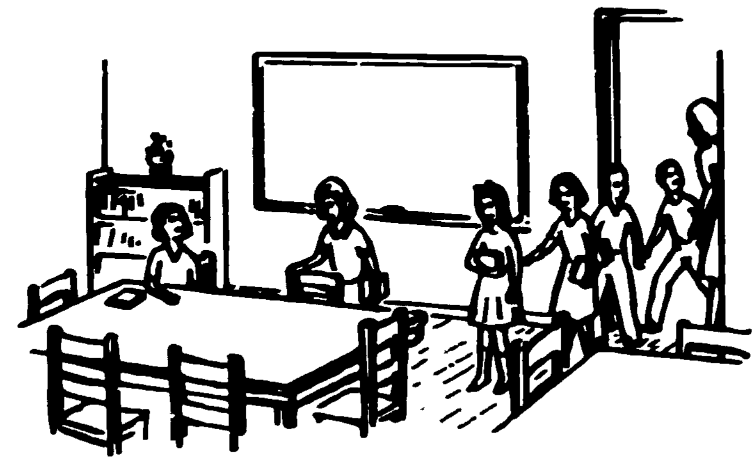
Children have individual small maps and draw in all their "shortest" ways to school, or the safest way to school. Children draw in stop lights, stop signs, label streets, find one-way streets, etc.

HOUSES THAT ARE TWO BLOCKS OR LESS FROM SCHOOL



The example is a city school where the writer taught 3rd graders. This was a group project. First we marked all the houses two blocks from the nearest school entrance; then we drew in the houses between.

C. HERE THEY ARE ASSIGNED TO A CLASSROOM (A GIVEN GEOGRAPHIC SPACE WITHIN THE BUILDING) AND EACH CHILD IN TURN IS GIVEN A SEAT AT A TABLE (A GIVEN GEOGRAPHIC SPACE WITHIN A ROOM).



What is the number of classrooms in the school?

On each floor?

What is the number of other rooms?

Approximately how many desks and chairs, children, teachers, books, windows, floor tiles, etc. . . are there in the school?

What are the dimensions of the classrooms? What is the ratio of length to width to height of floor and wall area?

What is the arrangement of desks — rows and columns or other arrangement (seating plan for the class)?

A homemade map of the school can be made from a trip through the halls.

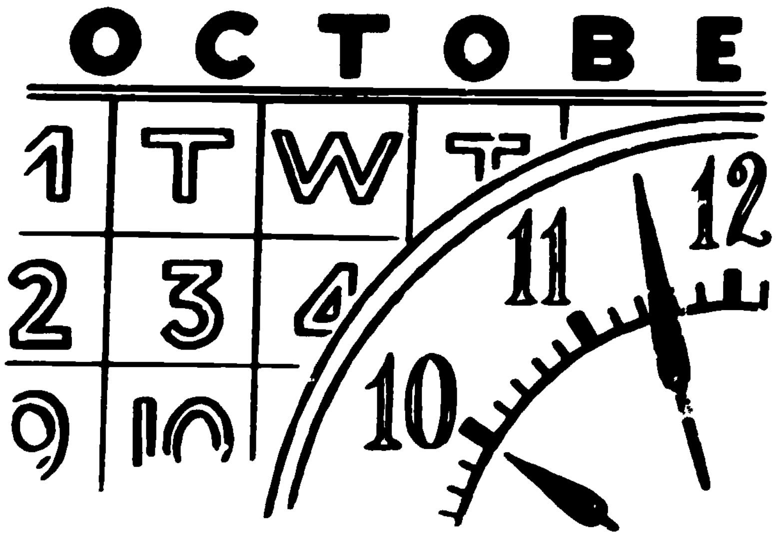
The perimeter of the building can be measured.

For older elementary grades, a trip through the school with copies of the school blueprints is recommended in order that the children can actually see the relationship of the plan to the building. They might want to sketch or take photos of certain views as seen on the blueprint.

Copies should be made of certain views of the blueprint and certain details (a window, a crossbeam, a bathroom) marked in color. Pairs of children may at convenient times borrow the prints and locate the marked detail in the actual building. They must come back with a good written description as to where it was.

Of course the inverse can be done. Children are given several locations in the real building and they must locate them on all the blueprints which include these.

D. THIS ORGANIZATION HOLDS ONLY FOR THE SCHOOL YEAR (A VERY SPECIFIC PART OF THE CALENDAR YEAR) AND THEN ONLY FOR THAT PART OF THE WEEK CALLED "THE SCHOOL WEEK" AND FOR ONLY THAT PART OF THE DAY CALLED "THE SCHOOL HOURS."



What is the ratio of school days to the total calendar days (and to non-school days), in a week, in a year?

What is the ratio of school hours to total hours in a day (and to non-school hours)?

Such questions encourage the child to use many different mathematical approaches.

I am in school for 1/4 of a 24 hour day.

5/7 of a calendar week are school days.

Therefore, I spend 1/4 of 5/7 of the hours in a week in school.

Of all the days of the calendar year, 200/365 are school days.

On those 200 school days, I am in school only 1/4 of the time, which amounts to 50 twenty-four hour days.

Therefore: 3/4 of 200 days + 4/4 of 165 days I am not in school.

3/4 of 200 = 150
150 + 165 = 315

315 twenty-four hour days I spend outside school. I would multiply 315 x 24 if I wanted to know how many hours this is. Every year of my elementary school life I will spend approximately 14% in school and 86% out of school. Of course, if I average 8 hours a day in sleep. I will spend another 33 1/3% or about 110 days on that. I wonder how many 24 hour-days I spend looking at TV?

II. The personal characteristics of individual children provide a rich source of material for study through set games, ratio comparison and graphing of class statistics.

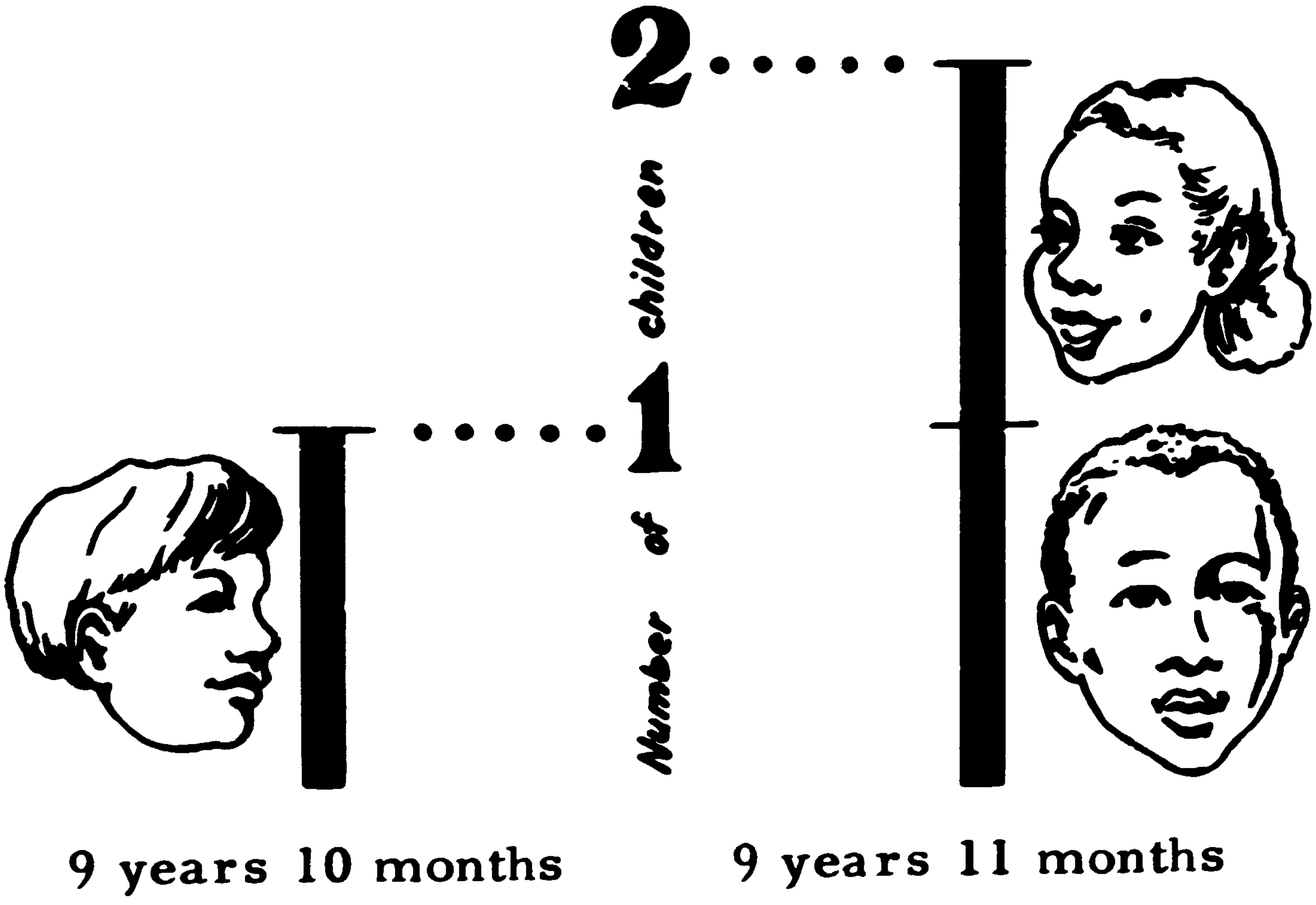
PERSONAL CHARACTERISTICS OF CHILDREN:

"My children are of different ages, heights, and weights. They come from families of different sizes. They have different hair and eye color, different interests and hobbies."

A SPECIAL WORD OF CAUTION

It is understood that the teacher will be sensitive to the implications of certain data for the individuals in a specific class (and for their families), in order to avoid any questions which might prove embarrassing.

A. MY CHILDREN ARE OF DIFFERENT AGES:



What is the age range of the children?

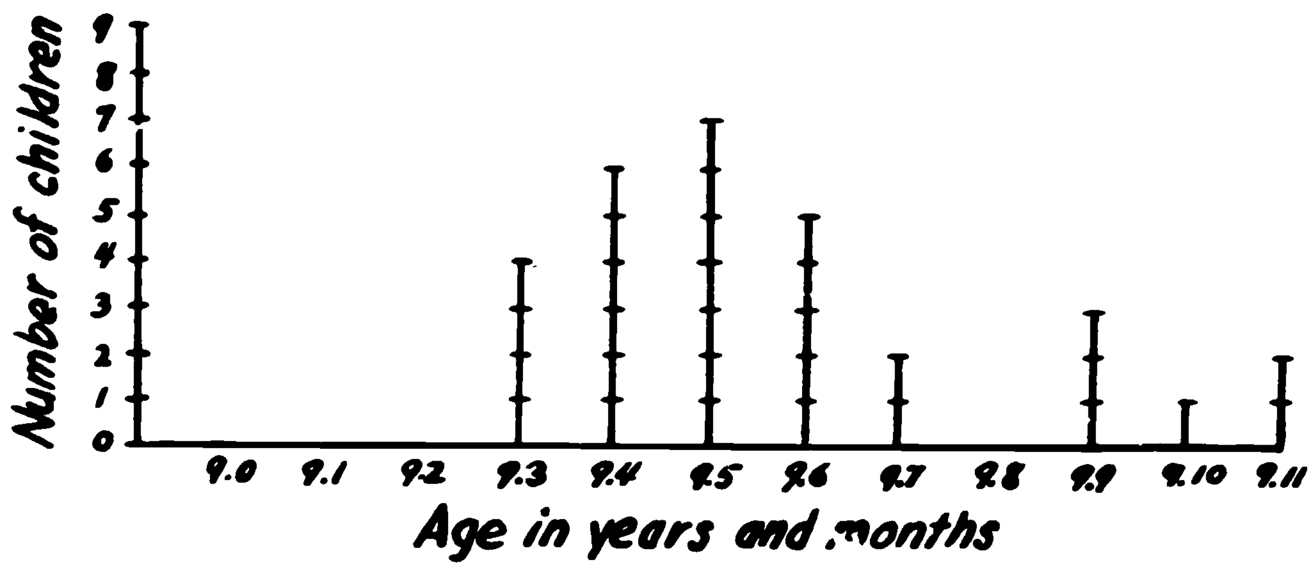
What is the age distribution?

What is the average age (years and months) of the class?

Would a bar graph of class birthdays by months give us answers to these questions?

What else would a bar graph tell us?

Age Profile for Thirty Children in Fourth Grade



From the chart we can see many relationships:

There is an 8-month spread between the youngest 4 and the oldest 2 children.

18 children (or 3/5 of the class) are within two months of one another's age.

The average age $\frac{\text{sum of ages}}{\text{number of children}}$ is a little less than 9 years 6 months.

The median age (middle score) is 9 years 5 months.

The mode (greatest number of children of a given age) is 9 years 5 months.

Height and weight can be treated in a similar way.

Changes in these statistics over time can also be recorded.

B. THE AGE (OR HEIGHT OR WEIGHT) OF AN INDIVIDUAL CHILD MAY BE EXPRESSED IN MANY WAYS:

How old is Warren B. in years? In months? In weeks? In days? Children may even want to compute their ages in hours, minutes or seconds — if they want to.

The record of an individual child's age might be as follows:

Warren B. was born May 9, 1956.

On October 17, 1965 I made a record of my age.

To the closest year I am 9 years old.

To the closest month I am 9 years, 5 months or 113 months old.

To the closest week I am 490 weeks old (9 x 52 + 152/7) (9 years + 152 days = 9 x 52 weeks + 152/7 weeks).

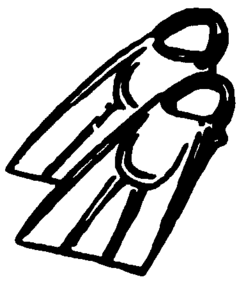
To the closest day I am 3439 days old (9 x 365 + 2 leap days + 152).

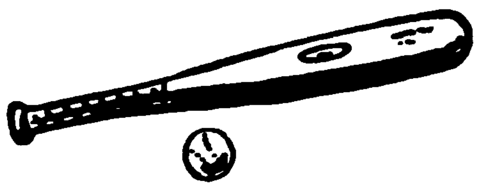
I know how to figure out the minutes but I don't want to know:
3439 x 24 x 60 will tell me how many minutes I am old.

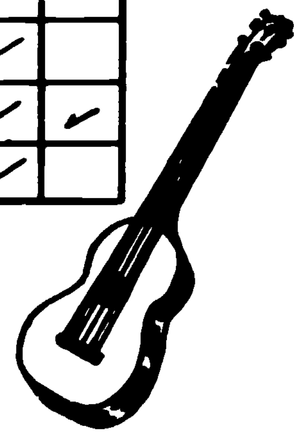
The writer had a whole class of third graders who wanted to figure out their ages in days. They used an office hand calculator to compute after they had set up the proble~s. One little girl wanted to know how many days the teacher had lived and .)en she saw what to her was an astronomically large number, she remarked very earnestly, "No wonder you are smarter than we are!"

C. THE INDIVIDUAL CHILDREN — PERSONAL DATA INVENTORY

	Joe	Tom	Bill	Sid	Gail	Ann	Dot	Liz
brown hair		✓					✓	
blonde hair	✓			✓				
black hair			✓		✓	✓		✓
blue eyes	✓				✓			
brown eyes		✓		✓		✓	✓	✓
other color eyes			✓					
plays instrument	✓		✓		✓	✓		✓
has pet	✓	✓			✓	✓	✓	
likes swimming	✓	✓	✓	✓	✓	✓	✓	✓
likes baseball	✓	✓	✓	✓			✓	





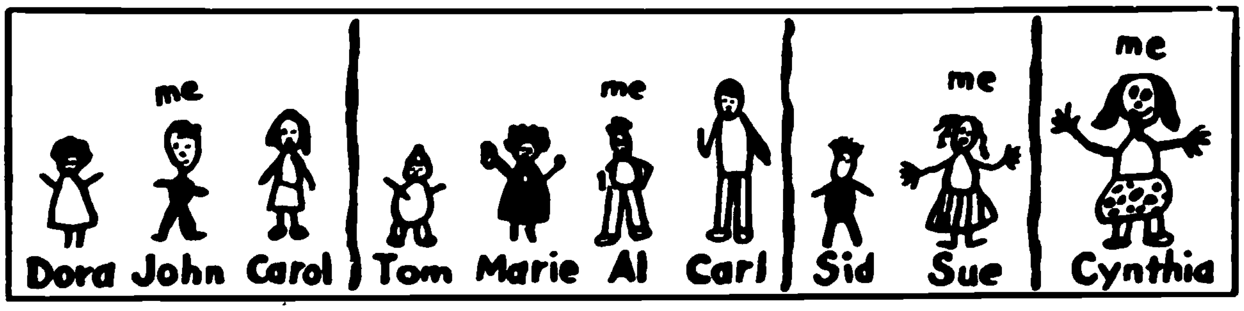


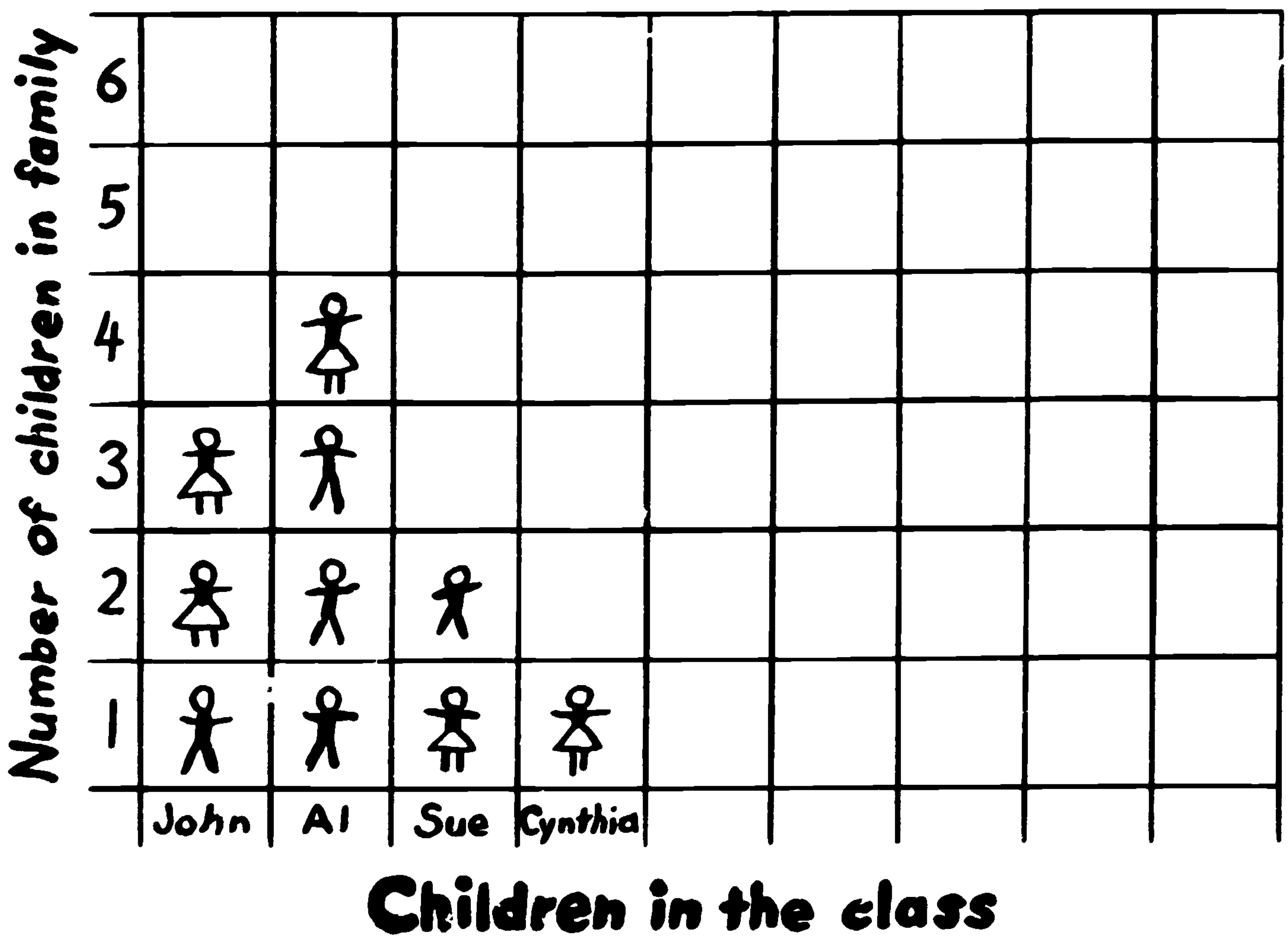
The members of the set of brown haired instrument players are __________:

Joe and Dot are the only members of the set of __________.

Who are the members of the set of black haired, pet owning swimmers? __________.

D. SMALLER CHILDREN ENJOY DRAWING "CHILDREN IN THE FAMILY PORTRAITS" WHICH MAKE AN INTERESTING FRIEZE AROUND THE CLASSROOM.





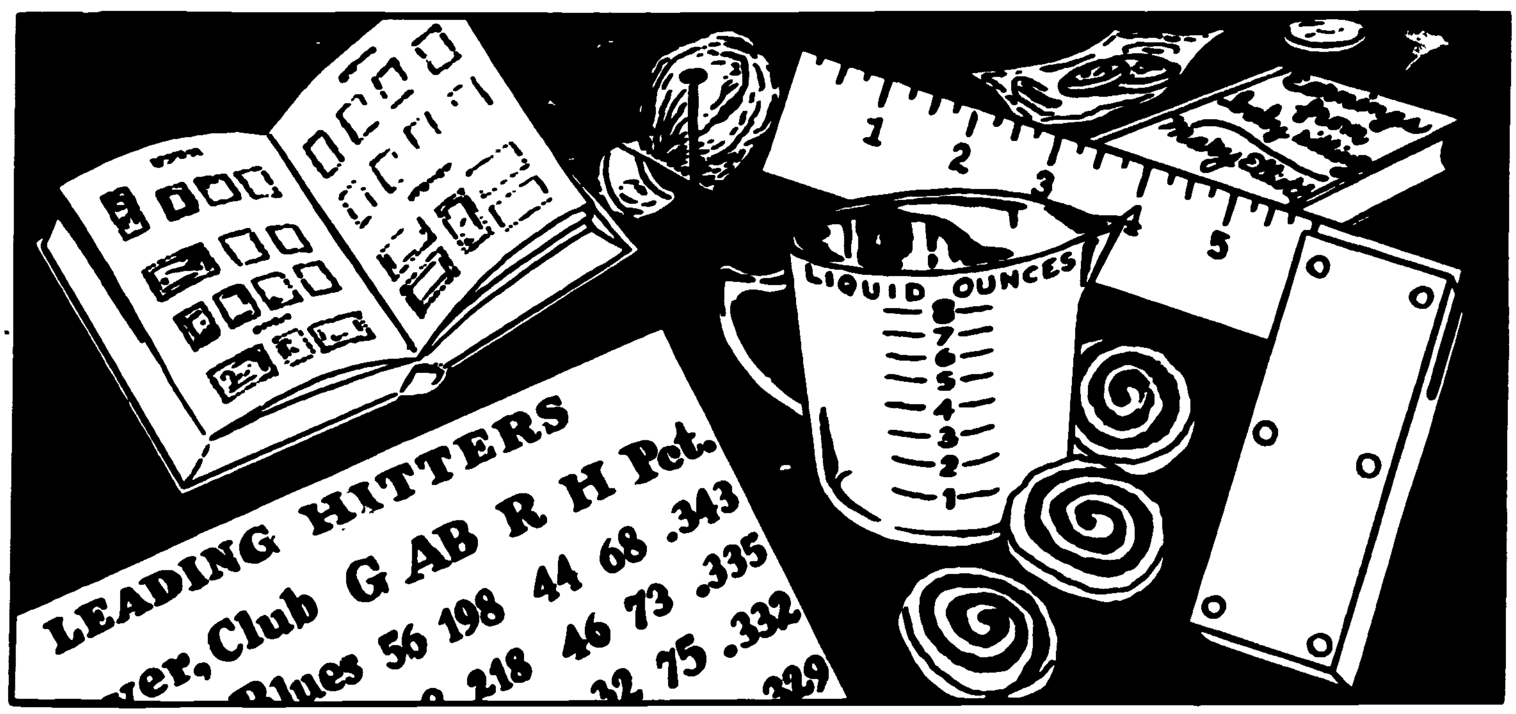
They delight in comparing the children in their families, counting the boys and girls, making up riddles about the chart.

E. HOBBIES ARE ALSO AN UNENDING SOURCE FOR PERSONALIZING MATHEMATICS.

Collections can be classified in various ways; for example, stamps can be classified by two criteria: 1. American 2. uncancelled. Combining the two criteria would result in a collection of American uncancelled stamps.

Keeping track of ball scores and batting averages is another rich source of mathematical activity. Planning and executing crafts as exemplified in graphing, weaving, and embroidery patterns allow for many kinds of mathematical thinking. The same may be said for model making, carpentry projects — especially when not working with a kit.

Following and altering recipes in cooking and baking employ applications of mathematical skills such as fractions, measurements of time. Business relations involved in and out of school, jobs from paper routes to baby sitting to shoveling snow give experience in earning power, hourly rates and budgeting.



III. WAYS OF THINKING ABOUT THE CURRICULUM MATHEMATICALLY

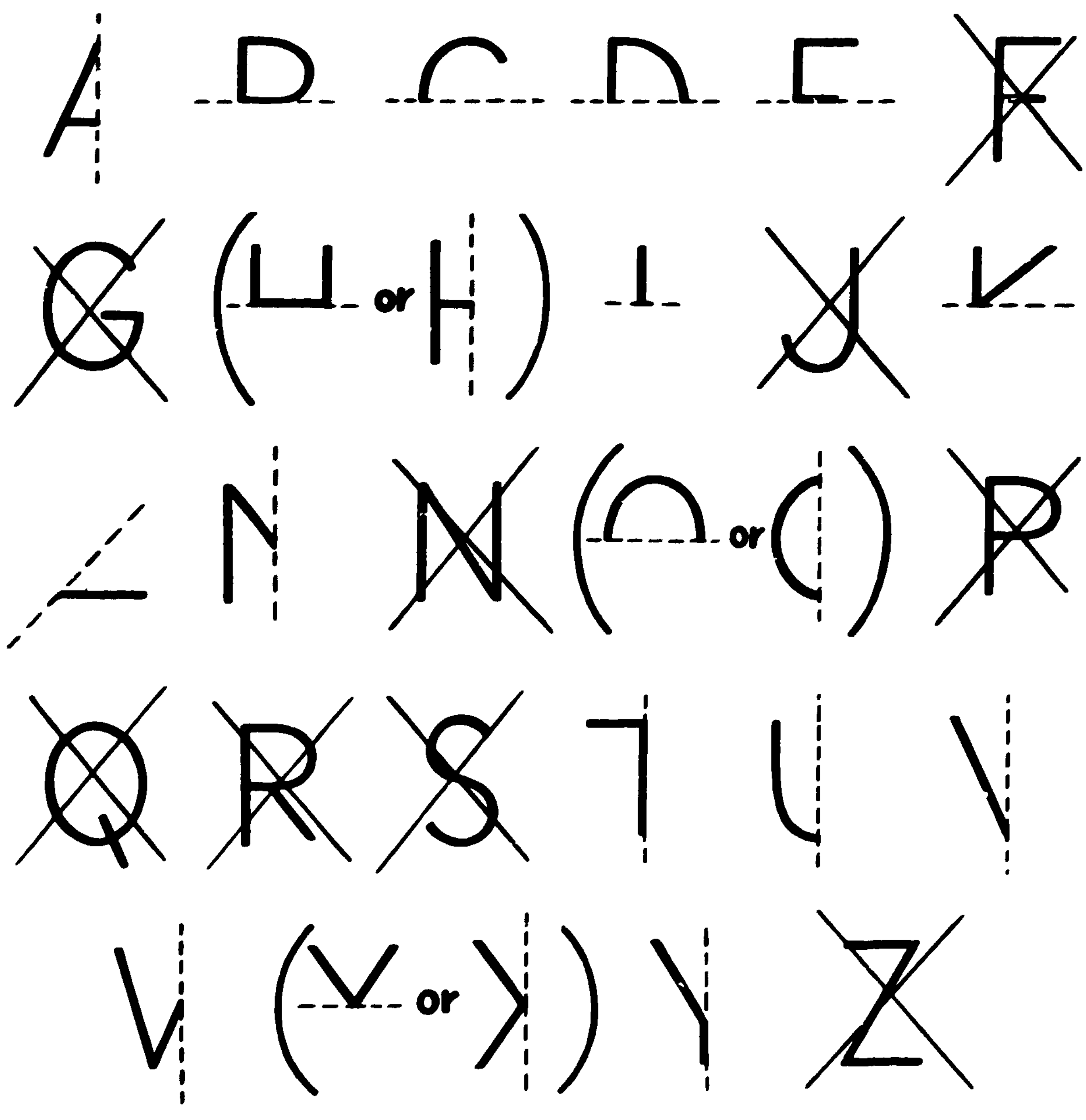
So far, we have only looked at the geography and geometry of the school surrounding and the characteristics of the children and look what an impressive list of activities we began!

The list becomes inexhaustable when we include the ways in which mathematical thinking and problem solving enters into other curricular areas. Let me illustrate this extensively in just one limited area; namely, the alphabet and the combination of letters that represent English.

A. THE GEOMETRY OF THE ALPHABET

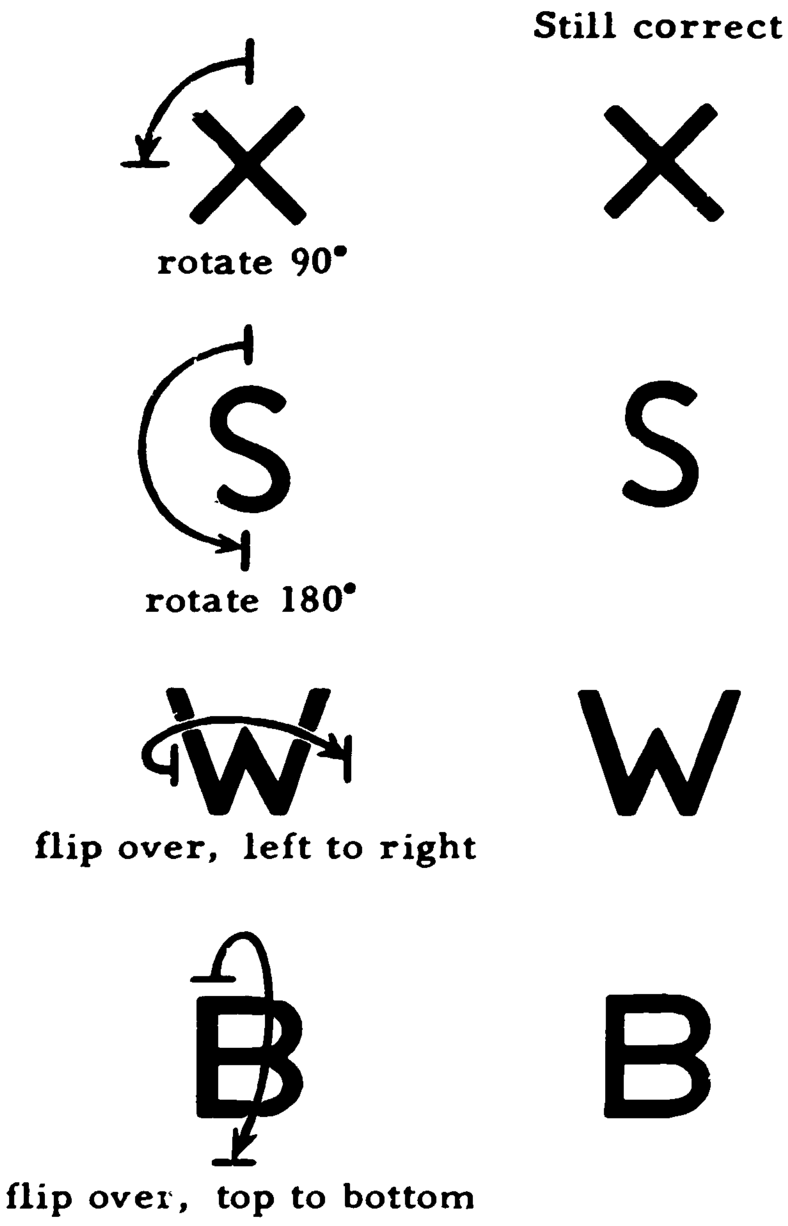
1. Even as a Kindergartener or First Grader learns the capital letters, he can strengthen his recognition by becoming aware of their geometric properties.
   A E F H I K L M N T V W X Y Z are all made of straight lines only; C D G J O P Q R S U are not.

2. Older children can use a mirror to find out which letters when only half drawn can be completed by their mirror image. This will introduce a study of symmetry.



Put mirror on dotted line to complete the letters.

3. The alphabet can also be sorted according to other principles; namely, whether the letter is still correctly formed after it is rotated 180 degrees or reflected and/or rotated.
The alphabet under rotation: X is the only letter which is still correct in 90 degree rotation.
X, H, I, O, N. S, Z are correct after a 180 degree rotation. They are the only letters with <u>points of symmetry</u>. The alphabet under reflection: When A H I M T V W X Y U O are flipped over left to right, they are still correct. This is because they have <u>vertical axes of symmetry</u>. When C E H I B D X O are flipped over top to bottom, they are still correct. This is because they have <u>horizontal axes of symmetry</u>.



Children enjoy seeking hidden principles of grouping in very familiar data. Here is an example using several ways of looking at the string of symbols making an English sentence:

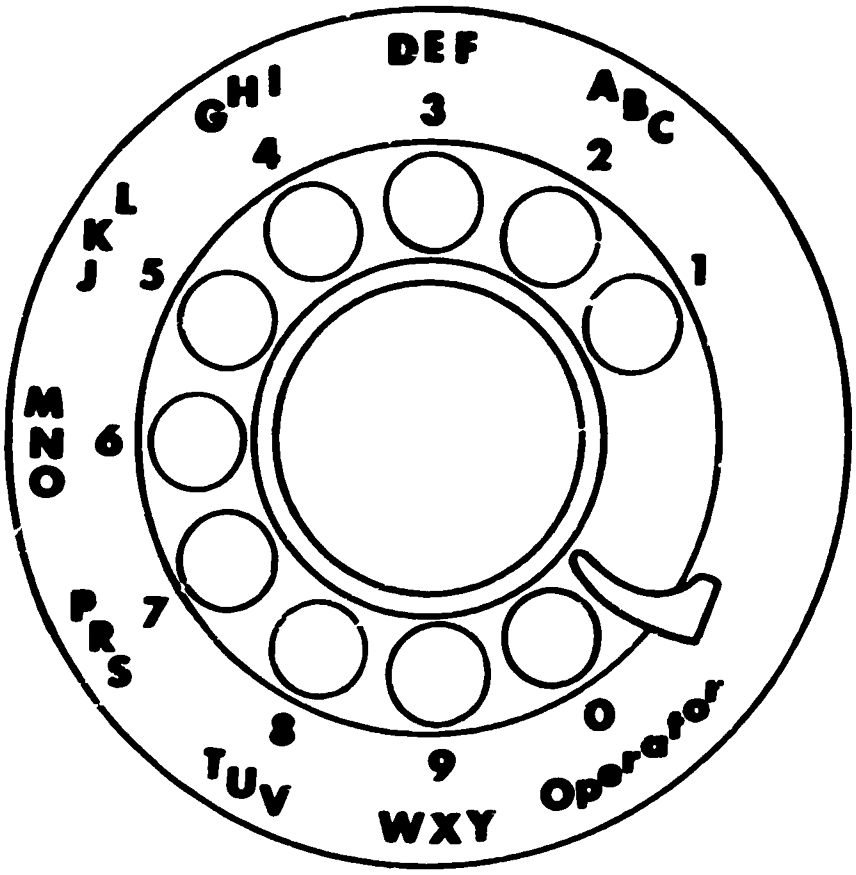
(1)	**WHAT**'S **THE** PROB**LEM**?	(Letters composed of straight lines only are thickened.)
(2)	WH**A**T'S TH**E** PR**O**BL**E**M?	(Vowels are thickened.)
(3)	WHAT'**S** THE **PR**OBLEM?	(Letters without mirror symmetry are thickened.)
(4)	W**HA**T'S T**HE** PRO**BLEM**?	(Letters in the first half of the alphabet are thickened.)
(5)	W**HAT**'S **THE** PROBL**E**M?	(Letters that cannot be drawn in one stroke without retracing are thickened.)
(6)	WH**A**T'S THE **PROB**LEM?	(Letters that include an enclosed space are thickened.)
(7)	**W**HA**T**'S T**H**E P**R**OB**L**EM?	(Thickened and thin letters alternate in a 1, 2, 1, 2 pattern.)
(8)	W**H**A**T**'S **THE** PROB**LE**M?	(Letters that have only right angles are thickened.)

B. THE ALPHABET AS A FINITE ARITHMETIC SYSTEM

Our alphabet is an example of a finite arithmetic system with 26 ordered elements (letters). It is a system in modulo 26 (mod 26). The clock is an example of a finite number system in mod. 12 while the week is an example in mod. 7.

"Alphabetizing" a set of data means rearranging them so that the ordering principle from A to Z is observed both between words and within words. Telephone books, dictionaries, indexes are only some of the examples of this use. To do this a one to one correspondence is set up between the counting numbers 1 - 26 and the letters A - Z with A $\leftrightarrow$ 1; B $\leftrightarrow$ 2; C $\leftrightarrow$ 3; D $\leftrightarrow$ 4; etc.

Apply this idea by reading the following message to you: 9 8, 15, 16, 5 25, 15, 21 1, 18, 5 19, 15, 20 2, 15, 18, 5, 4 18, 5, 1, 4, 9, 14, 7 20, 8, 9, 19.



C. OTHER TYPES OF MATHEMATICS GROWING OUT OF AN ANALYSIS OF THE USE OF THE ALPHABET TO WRITE ENGLISH IN ENGLISH SPELLING.

1. What is the ratio between one to five letter words and six to nine letter words in some sample books? Different types of writing can be examined, such as popular vs. scientific writing.

2. What is the ratio between vowels and consonants?

3. What would you guess are the most frequently-used letters in English writing? Or the least frequently-used letters? How could a class organize itself to do some research on this question? How could they represent their findings graphically? What would they learn about statistics through this exercise?

4. What are the longest consonant or vowel clusters in English writing? What are the most frequently-used clusters and blends?

5. Could we still decipher a piece of writing on a familiar subject if all the vowels were eliminated?

Wld th sm hld fr cnsnnts?

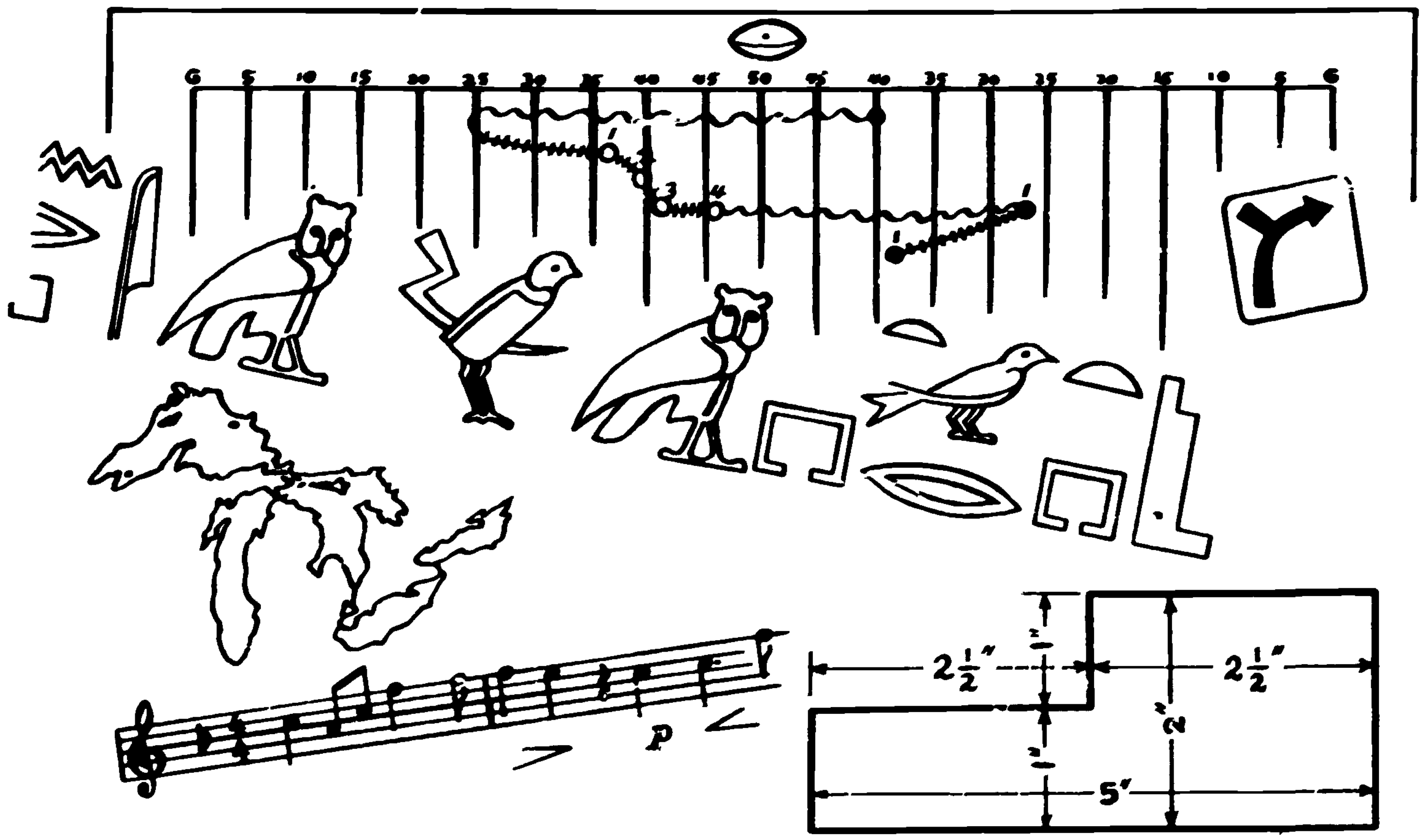
(Would the same hold for consonants?)

6. Why do we have non-symbol letters in writing? What are they? What do they signal? Can we set these non-letter symbols into correspondence with oral speech behavior such as pauses, stress, intonation, volume, pitch, etc.? Does mathematics have similar non-numeral and non-operator symbols which erase ambiguity in mathematical writing but which are not needed in speech? Answer: Yes, $4 + 3 \times 2 = 14$ and $4 + 3 \times 2 = 10$ are both correct depending upon how one groups for the operations. Speech makes this clear by pauses. Writing needs to use parentheses. $(4 + 3) \times 2 = 14$ $4 + (3 \times 2) = 10$.

D. ALPHABETIC WRITINGS VERSUS OTHER KINDS OF WRITING:

1. Why can a Russian child find the answer to $[(5 + 7) \times 6] - 8$ as easily as an American child? What kind of symbols are numerals, operators, brackets?
   Which depends more on speech sounds, mathematical notation or alphabetic writing?
   Which is more universally understood?

2. What other kinds of written representation systems exist besides alphabetic writing and equation writing?



What are the rules used by each?

END OF PART I

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